# Status Update on the NCRP Scientific Committee SC 5-1 Report: Decision Making for Late-Phase Recovery from Nuclear or Radiological Incidents - 13450

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## ABSTRACT

In August 2008, the U.S. Department of Homeland Security (DHS) issued its final Protective Action Guide (PAG) for radiological dispersal device (RDD) and improvised nuclear device (IND) incidents. This document specifies protective actions for public health during the early and intermediate phases and cleanup guidance for the late phase of RDD or IND incidents, and it discusses approaches to implementing the necessary actions. However, while the PAG provides specific guidance for the early and intermediate phases, it prescribes no equivalent guidance for the late-phase cleanup actions. Instead, the PAG offers a general description of a complex process using a site-specific optimization approach. This approach does not predetermine cleanup levels but approaches the problem from the factors that would bear on the final agreed-on cleanup levels. Based on this approach, the decision-making process involves multifaceted considerations including public health, the environment, and the economy, as well as sociopolitical factors. In an effort to fully define the process and approach to be used in optimizing late-phase recovery and site restoration following an RDD or IND incident, DHS has tasked the NCRP with preparing a comprehensive report addressing all aspects of the optimization process. Preparation of the NCRP report is a three-year (2010–2013) project assigned to a scientific committee, the Scientific Committee (SC) 5-1; the report was initially titled, *Approach to Optimizing Decision Making for Late-Phase Recovery from Nuclear or Radiological Terrorism Incidents*. Members of SC 5-1 represent a broad range of expertise, including homeland security, health physics, risk and decision analysis, economics, environmental remediation and radioactive waste management, and communication. In the wake of the Fukushima nuclear accident of 2011, and guided by a recent process led by the White House through a Principal Level Exercise (PLE), the optimization approach has since been expanded to include off-site contamination from major nuclear power plant accidents as well as other nuclear or radiological incidents. The expanded application under the current guidance has thus led to a broadened scope of the report, which is reflected in its new title, *Decision Making for Late-Phase Recovery from Nuclear or Radiological Incidents*.

The NCRP report, which is due for publication in 2013, will substantiate the current DHS guidance by clarifying and elaborating on the processes required for the development and implementation of procedures for optimizing decision making for late-phase recovery, enabling the establishment of cleanup goals on a site-specific basis. The report will contain a series of topics addressing important issues related to the long-term recovery from nuclear or radiological incidents. Special topics relevant to supporting the optimization of the decision-making process will include cost-benefit analysis, radioactive waste management, risk communication, stakeholder interaction, risk assessment, and decontamination approaches and techniques. The committee also evaluated past nuclear and radiological incidents for their relevance to the report, including the emerging issues associated with the Fukushima nuclear accident. Thus, due to the commonality of the late-phase issues (such as the potential widespread contamination following an event), the majority of the information pertaining to the response in the late-phase decision-making period, including site-specific optimization framework and approach, could be used or adapted for use in case of similar situations that are not due to terrorism, such as those that would be caused by major nuclear facility accidents or radiological incidents. To ensure that the report and the NCRP recommendations are current and relevant to the effective implementation of federal guidance, SC 5-1 has actively coordinated with the agencies of interest and other relevant stakeholders throughout

the duration of the project. The resulting report will be an important resource to guide those involved in late-phase recovery efforts following a nuclear or radiological incident.

## INTRODUCTION

Subsequent to the terrorist events of September 11, 2001, many activities have been undertaken, both in the United States and at the international level, to address the response to and management of terrorist events. One specific area of concern involves the use of radioactive or nuclear material in such events in the forms known as radiological dispersal devices (RDDs) or improvised nuclear devices (INDs).

While the current effort on emergency preparedness has been focused primarily on triaging the initial response to the event, society has been slow in addressing the more complex, long-term recovery issues in the aftermath of the event [1, 2]. For an RDD event specifically, an overwhelming concern is the potentially widespread contamination of radioactive materials over the affected communities, causing considerable disruption to society. A thorough emergency planning effort for an RDD event would thus require specific guidance on long-term recovery as relevant issues began to surface in the recent TOPOFF exercises [3] and Empire 09 [4], and became further exemplified in the latest Liberty RadEx Exercise of 2010 for recovery from a postulated RDD event [5].

On August 1, 2008, U.S. Department of Homeland Security (DHS) issued an important final guidance document titled *Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents* [6]. The guidance provides Protective Action Guides (PAGs) to support decisions on actions to be undertaken to protect the general public and emergency workers. The guidance offers explicit PAGs for both early and intermediate phases. The early phase (also known as the emergency phase) is the period at the beginning of an incident when immediate decisions for effective use of protective actions are required and actual field measurement data are generally not available. The intermediate phase follows the early phase; it begins after the source and releases have been brought under control and protective action decisions can be made based on measurements of exposure and the radioactive materials that have been deposited as a result of the incident.

For the late-phase response (i.e., long-term recovery and restoration), the guidance prescribes a process for deriving a long-term plan in lieu of a predetermined cleanup level. This approach involves a site-specific "optimization" process, following the principle of *justification*, for developing the appropriate cleanup criterion for the contaminated area. The principle of *optimization of protection* has been advocated by the ICRP [7]. The primary objective of late-phase activities is to help restore conditions and return the community to a "new normal" in the most expedient manner. However, the approach to a full recovery is likely to be multifaceted and involve a high level of complexity. That is, setting a priority for a particular decision will inevitably involve tradeoffs among many key factors and will also entail complex deliberations in reaching "optimization."

In 2010, DHS commissioned the NCRP to prepare a comprehensive report addressing all aspects of the optimization process. The three-year (2010–2013) effort to prepare the NCRP report, titled Approach to *Optimizing Decision Making for Late-Phase Recovery from Nuclear or Radiological Terrorism Incidents*, was undertaken by a scientific committee designated as Scientific Committee (SC) 5-1. Members of SC 5-1 represent a broad range of expertise, including homeland security, health physics, risk and decision analysis, economics, environmental remediation and radioactive waste management, and communication.

In March 2011, a major nuclear reactor accident occurred at the Fukushima Daiichi nuclear facility in Japan [8]. It was the largest nuclear accident in Japan's history and the second-largest nuclear accident in the history of mankind, the largest being the 1986 Chernobyl nuclear accident in Ukraine [9], in the former Soviet Union. The combined disaster at Fukushima was initiated by an earthquake and subsequently by a tsunami; the resulting nuclear accident created an unprecedented situation that has challenged the modern society of Japan. The accident caught worldwide attention and led to more in-depth evaluations toward better preparedness for such events in the future. In the United States, for example, a Principal Level Exercise (PLE) was coordinated by the White House in 2012 with radiation guidance provided for the late-phase remediation cleanup process for incidents involving nuclear power plants, RDDs, or INDs. Because of the need to fully incorporate the latest information and guidance on the late-phase recovery for all nuclear and radiological incidents, the title of the SC 5-1 report was revised as *Decision Making for Late-Phase Recovery from Nuclear or Radiological Incidents*. Discussed below are some of the issues and considerations being deliberated by the committee.

## OPTIMIZING DECISION MAKING – APPROACH AND PROCESS

### Late-Phase Recovery Considerations

The late phase (or recovery phase), which follows the intermediate phase, represents the stage at which residual radiation levels from the event are reduced to acceptable levels, allowing a return to a state of normalcy (or a new normal), which may last for many years following the occurrence of the event. The PAGs issued by DHS contain specific dose limits for response actions in both early and intermediate phases, but do not recommend specific dose limits for the late phase. Instead, the PAG for the late phase recommends that the late-phase cleanup be achieved through a "site-specific optimization process." It states, "Because of the extremely broad range of potential impacts that may occur from RDDs or INDs…a pre-established numerical cleanup guideline is not recommended as the best serving the needs of decision makers in the late phase."

Regardless of the scenario, one common long-term concern is the potentially widespread radioactive contamination of critical infrastructures as well as public or private properties (including those in highly populated metropolitan areas) that would require an extensive mitigation effort. Several important factors, among others, would likely weigh heavily in the decision-making process: the requirement of tremendous amounts of resources, the substantial funding commitment, and stakeholder acceptance of the cleanup options and goals. The challenge to develop suitable guidance for late-phase recovery efforts will therefore be influenced by these as well as other considerations in subsequent deliberations surrounding the related issues.

The late-phase recovery issues have three focus areas: (1) characterization and stabilization, (2) development of goals and strategies, and (3) implementation and reoccupancy. It must be emphasized that the decision-making process is aimed at achieving a timely recovery using the most expedient approach that takes into account available resources and constraints.

### Optimization Concept and Principle

The concept of optimization has been advocated by international and national regulatory and advisory bodies, and is also commonly practiced by all levels of government in decision-making processes. The ICRP has prescribed basic principles for protection against radiation [7]. Of particular relevance is the fact that ICRP has advocated use of the principle of optimization of protection, which maintains that the likelihood of exposure, the number of people exposed, and the magnitude of individual doses "should all be kept as low as reasonably achievable, taking into account economic and societal factors." This objective is commonly referred to as the ALARA principle and has been affirmed by the NCRP [10]. The ALARA principle has thus been a requirement in all existing regulations for control of radiation exposures, including the statutes on cleanup of nuclear facilities. It is also considered as being "graded" in scope, taking into consideration the magnitude of the potential impact [11]. Implementation of the cleanup decision thus requires input from all relevant stakeholders, while accounting for a broad set of long-term objectives. The protection guidance for living in existing exposure situations is prescribed by ICRP Report 111 [12]. Pursuant to this guidance, the cleanup criteria will be developed based on a reference level range from 1 mSy/y to 20 mSv/y, together with the application of the ALARA principle.

One key reason that no specific level was recommended for late-phase recovery is that the potential impacts of RDD or IND incidents vary widely from minor to severe, so it may not be practical to use predetermined criteria for the cleanup and site restoration efforts.

**Approach and Implementation**

For late-phase response (i.e., long-term cleanup), the guidance prescribes a process for deriving a long-term plan, in lieu of a predetermined cleanup level, in which site-specific situations are properly balanced. This approach entails a site-specific "optimization" process for determining the appropriate cleanup criteria for the contaminated area. Compared to either early- or intermediate-phase responses, decision makers would have more time to deliberate on the late-phase recovery issues. The primary goal of optimization is to establish societal objectives that include possible future land uses, cleanup options and approaches, technical feasibility, costs, cost-effectiveness, infrastructures, the local economy, and ultimately public acceptance. In addition, optimization is to be achieved by a flexible and multifaceted decision-making process that takes incident- and site-specific factors into consideration. For example, a small-scale incident may receive an expedited cleanup effort, while an incident causing extensive contamination (e.g., affecting many city blocks in a major urban area) may warrant considerable effort (e.g., in terms of costs and time), thus influencing the decision on the final cleanup criteria.

Any criteria chosen will include consideration of existing federal statutory requirements on environmental cleanup (such as EPA's Superfund Program [13] and the NRC's rule on license termination [14]), along with other national and international recommendations. A host of relevant variables must also be considered, such as the extent and type of contamination, human and environmental health protection, and technological feasibility. However, it must be kept in mind that the optimization principle will have to encompass factors beyond long-term health effects to include other priority issues facing the event-disrupted society [15]. These factors may include the local economy, health care services, critical infrastructures, transportation systems, public security protection, and employment opportunities. Thus, the goal of optimization favors the overall well-being of society rather than simply focusing on limited issues for cleanup purposes. The deliberation on cleanup goals and criteria would be developed under the existing emergency management structure by incorporating appropriate technical entities and stakeholders in the decision-making process.

The optimization process, therefore, would include several important elements. These include: impact assessment, identifying and evaluating viable options, setting criteria and priorities, evaluating and deploying appropriate technologies, implementation, and long-term monitoring. It is important to keep in mind that all of these efforts require extensive involvement with stakeholders in gaining a consensus and reaching the final decision. Due to its complexity, the optimization process is necessarily flexible, interactive, and also based on a graded approach, one that always emphasizes priority issues as the process evolves.

## KEY ASPECTS OF OPTIMIZATION

The following are some important considerations for optimization of the decision-making process.

**Resilience of Recovery**

For a region adversely impacted by a disruptive event, the ultimate recovery would be defined by the return of the communities to a "new normal." The term *resilience* has the following definition: *the capacity of a system to absorb disturbance, undergo change, and retain the same essential functions, structure, identity, and feedbacks* [16]. Resilience is measured by a combination of resource robustness and the adaptive capability of the communities in response to the event [16]. In addition, timeliness to recovery is essential for a highly resilient community, given the robustness of its resources and its adaptive capability; the contrary is true for a community having low resilience. To accomplish a timely recovery, sufficient incentives would be required; and the primary "drivers" toward recovery would include political, economic, and cultural factors, with each factor contributing to the collective desire of the community to return to a norm in life. One important aspect of the "whole community" approach [17] to a major disastrous event involves properly integrating the constituent communities into the recovery planning process. One important element for enhancing resource robustness and adaptive capability is to develop and promote a community "self-help" program during the planning process. However, such a program would be specific to the event and the region. Thus, proper planning to allow the incorporation of such a program needs to be identified and carried out with respect to a specific response [12].

**Setting Priority**

The task of cleaning up a massive area following a nuclear or radiological event requires unprecedented resources, manpower, and technology, as well as a substantial funding commitment. For protection of populations living in an existing exposure condition, the principle of optimization of protection has been advocated by the ICRP [7]. To this end, optimization is intended to address the very urgent issues facing an event-disrupted society, including the local economy, available health care facilities, functional transportation systems, educational capabilities, and public employment. The IAEA recently reiterated its advice to Japanese authorities on the importance of practicing the optimization principle (and to avoid "over-conservatism") for cleaning up the contaminated areas affected by the Fukushima nuclear accident of 2011 [18]. Furthermore, care must also be exercised to avoid potential adverse ecological impacts to the environment that could be caused by an excessive cleanup effort [19]. Accordingly, the predetermined, prescriptive cleanup levels, such as those required by existing government regulations under the statutory cleanup provisions, may not be feasible or even possibly address the highly complex issues resulted from a major nuclear incident [20].

**Communication and Stakeholders Involvement**

Incorporating stakeholders in the process of the response to an event is central to the "whole community" concept [17]. Thus, the pre-event planning effort ought to reach out and identify various levels and groups of stakeholders who are to be consulted on major decisions through a series of collaborative proceedings. Such interactions would have to continue through the recovery phase and perhaps beyond. By doing so, it is important to recognize the cultural, racial, social, economic, and religious diversity of the affected society. In addition, there may be a multitude of stakeholder groups in various decision-making processes, some of which may contain inherent conflicts of their own. In such cases, potentially conflicting interests may develop among the different groups of stakeholders representing the municipal area, the temporary staging areas, and the ultimate disposal area. Thus all such issues need to be identified by the pre-event planning effort and be frequently exercised and coordinated to resolve the potential conflicts or issues. The continued effort in reaching out and engaging relevant stakeholders is therefore essential for reaching acceptable decisions for long-term recovery.

### Incorporation of Science and Technology

The event-specific situations generally would require specific state-of-the-art information and technology in order to expedite the cleanup process that is specific to the incident. This is, in addition to a host of similar knowledge and technologies developed over the past decades in addressing the cleanup situations by the nuclear industry. Much of the existing experience may become obsolete or inappropriate when it comes to addressing the specific contamination situations as created by the event in a particular region. For example, an extensive areal contamination in soils such as in the Chernobyl nuclear accident [9] or in the Fukushima nuclear accident [18] cannot be addressed merely by the routine excavation methods that are commonly used in the decommissioning activities of nuclear facilities. The pervasive existence of contamination by Cs-137, for example, has resulted in recommended methods, such as deep plowing, to mitigate soil contamination issues over wide areas. Continued research and development is needed to enhance and improve on the effectiveness and availability of these technologies; as exemplified by a recent plan to intensify the research effort by the Japanese Government in addressing the environmental contamination issues pertaining to the Fukushima accident [21].

### Long-Term Monitoring and Follow-up

It is prudent to continue monitoring public health and environmental conditions for an extended period of time following a major event. In addition to ensuring that no adverse effects would exist by the exposure during and after the event [12], the effort would offer further assurance to the public to foster a positive perception. Additionally, environmental contamination following a major event may linger for many years to come, especially in some areas (such as forests) that may not receive sufficient priority or resources to complete the cleanup due to limitations. In such circumstances, imposition of necessary constraints for access, consumption of food products, or monitoring for possible migration of the contamination would be warranted.

## LESSONS LEARNED FROM HISTORIC EVENTS

While the late-phase guidance developed by DHS offers a logical framework for the optimization process, it still lacks specificity and technical substance on how to reach cleanup decisions. In particular, given that the complexity of a cleanup is highly dependent on site-specific factors, several issues particularly critical to the decision-making process require more in-depth consideration. Because past terrorist events involving nuclear or radiological sources are rare, much of the information and lessons learned must rely heavily on events that were accidental in nature. Furthermore, much of the concern associated with long-term recovery issues would share some common attributes whether they originated from terrorist acts or not. Accordingly, a review of the historic events would provide valuable input to developing guidance for any future events. The past events would be evaluated for their relevancy to the optimization issues discussed above.

### Review of Historic Events

Such issues have been recognized and addressed in past events of similar nature, and varying degrees of relevancy can be systematically captured in the form of lessons learned. Four categories of the events are evaluated: (1) events involving terrorist acts, (2) incidents involving nuclear facilities or sites, (3) events associated with atomic testing or war activities, and (4) recent planning exercises in the United States involving nuclear or radiological terrorism. Depending their availability or relevancy, cases will be described as examples that may carry some important attributes that pertain to long-term late-phase recovery. For events that are not directly linked to terrorist acts, the focus tends to be on the widespread contamination of the involved release from radioactive sources. These include some major or significant nuclear/radiological accidents in recent history [22]. These events ranged from a localized terrorist event involving Po-210 due to a former Soviet spy in London, UK (2006) [23], to the very large-scale nuclear accident involving a reactor in Chernobyl, Ukraine (1986) [9]. Among the events evaluated is the most recent nuclear accident at Fukushima, Japan (2011) [8], which was caused by a major earthquake and ensuing impact by a tsunami in March 2011, for which the recovery issues are still evolving while being addressed. Also discussed have been recent large-scale exercises that took place in the United States that were aimed at addressing the preparedness against nuclear or radiological incidents and for which long-term recovery would be an important consideration.

### The Fukushima Nuclear Accident and Its Influence

On March 1, 2011, Japan suffered its most tragic nuclear accident at the Fukushima Daiichi Nuclear Power Station [8]. The accident was caused by an unprecedented earthquake and a subsequent tsunami that incapacitated the reactors on site. Although no death was caused by the radiation itself, hundreds of thousands of people have since been evacuated. The subsequent release of radioactive materials during the accident beyond the damaged reactors resulted in a wide area of contamination across the region. By late 2011, the contaminated areas that may require remediation were estimated to be 13,000 $km^2$ (or roughly the size of the State of Connecticut; based on a dose criterion of 1 mSv/yr, or 100 mrem/yr), for which the radioactive waste volume generated is estimated to reach 29 million cubic meters, and the decontamination costs being on the order of $15.6 billion [24]. The recovery effort began in late 2011, and by October, IAEA issued its preliminary findings related to the initial efforts undertaken by the Japanese Government [18]; there, many of the issues discussed earlier were mentioned along with the inclusion of site-specific issues.

## STATUS OF THE NCRP REPORT

The primary focus of the NCRP report will be on the issues associated with optimization of decision making pertaining to long-term recovery following a nuclear or radiological incident. To this end, it will address the aforementioned considerations and incorporate the basic radiation protection principles, approaches, and implementation methods for preparedness and response to such events. Thus, the report will consider inclusion of the following topics:

- A decision framework for addressing late-phase recovery issues,
- Identification of the affected basic and critical infrastructures and key factors needed for decision making,
- A description of the optimization principles and the implementation process,
- Evaluation of lessons learned from historic events,
- Description of some practical operational aspects to illustrate the process, and
- Consolidated recommendations for late-phase recovery.

To ensure that the report and NCRP recommendations are as current and relevant to the effective implementation of federal guidance, it has actively coordinated with the agencies of interest and other relevant stakeholders throughout the project period, thereby ensuring proper and timely incorporation of all relevant information that is available for the development of applicable and effective recommendations. For example, as a parallel effort to DHS's guidance, the EPA is in the process of updating its own guidance document, *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents,* EPA 400-R-92-001 (1992) [25].

This NCRP report will include a risk management framework to manage a federal remediation strategy that addresses the organization and administration of the optimization process that will support cleanup and restoration decisions. The purpose of the proposed NCRP report will be to provide a framework and to develop guiding procedures for implementing the optimization process by:

- Identifying key elements and the basic framework for optimization of the late-phase recovery effort,
- Identifying key decision factors involved in restoring or remediating the critical infrastructures and the affected components of the community,
- Developing hierarchical parameters that help to characterize the priority of the potential actions in returning the community to normalcy, and
- Developing the basis and procedural approach toward implementing optimization to support decision-making, including the identification of necessary tools and techniques.

The report, which is due for publication in 2013, will also provide guidance and a basis for implementing the optimizing decision making to address late-phase recovery issues in the event of a nuclear or radiological incident. .

## CONCLUSIONS

The current guidance issued by DHS presents a starting point for the long-term cleanup of sites contaminated by an RDD or IND incident. Nevertheless, further clarification and elaborated processes are still required for both the development and implementation of optimization procedures for setting cleanup and site restoration goals.

In recent years, national advisory bodies such as NCRP have devoted considerable effort to developing general guidance related to homeland security. NCRP, for example, has developed a considerable body of guidance on preparing for, and responding to, RDDs and INDs. The report that is currently being prepared will serve to complement a series of NCRP-developed guidance documents represented by: NCRP Report No.138 (2001), *Management of Terrorist Events Involving Radioactive Material* [26]; Commentary No. 19 (2005), *Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism* [27]; Commentary No. 20 (2007), *Radiation Protection and Measurement Issues Related to Cargo Scanning with Accelerator-Produced High-Energy X Rays* [28], and Report 165 , *Responding to Radiological and Nuclear Terrorism: A Guide for Decision Makers* (2010) [29]. Another report related to environmental remediation management is NCRP Report No.146 (2004), *Approaches to Risk Management in Remediation of Radioactively Contaminated Sites* [30].

The report to be prepared by SC5-1 will be an important resource and guidance for those involved in late-phase recovery efforts, whether accidental or resulting from an act of terrorism. Timely development of guidance on the late-phase optimization process is very much needed by society and across the world in order to strengthen the preparedness against the potential disastrous events in the future.

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